Access: Femoral, Radial, Brachial, Carotid

2

Femoral Access Using Modified Seldinger Technique

- Prepare the micropuncture equipment by inserting the dilator into the 4 Fr sheath (Fig. 2.1).
- Partially pull out the 0.018″ guidewire provided in the kit from its sheath, to ensure no difficulties will be encountered in introducing it into the needle.
- Keep these items on a towel spread close to the draped groin, so that they can be retrieved readily during access, without having to stretch out, or having to let go of the needle in the vessel.
- After the groin region is appropriately prepped and draped, palpate the pulse for femoral artery.
  - Span from the anterior, superior iliac crest to the pubic symphysis with left hand to approximate the ilioinguinal ligament. Bisect the span with right hand, which indicates the location of femoral artery. Palpate for the pulsations of the femoral artery at this spot (Fig. 2.2a).
  - One may also confirm the planned puncture site by placing tip of hemostat or scissors over the pulse and visualizing its relationship to the femoral head fluoroscopically. The femoral artery should be punctured at the inferomedial aspect of the femoral head.
- Immobilize a segment of the artery between the index and middle fingers of left hand.
- Infiltrate the skin overlying the immobilized segment with local anesthesia, using 1% lidocaine with epinephrine.
- Also infiltrate the tissues overlying the artery, aspirating prior to injecting, to ensure the lidocaine is not administered into the arterial lumen. If the artery lumen is entered, blood will be aspirated into the syringe, indicating that the needle needs to be withdrawn.
- Make a small, superficial stab incision in the skin overlying the immobilized segment.

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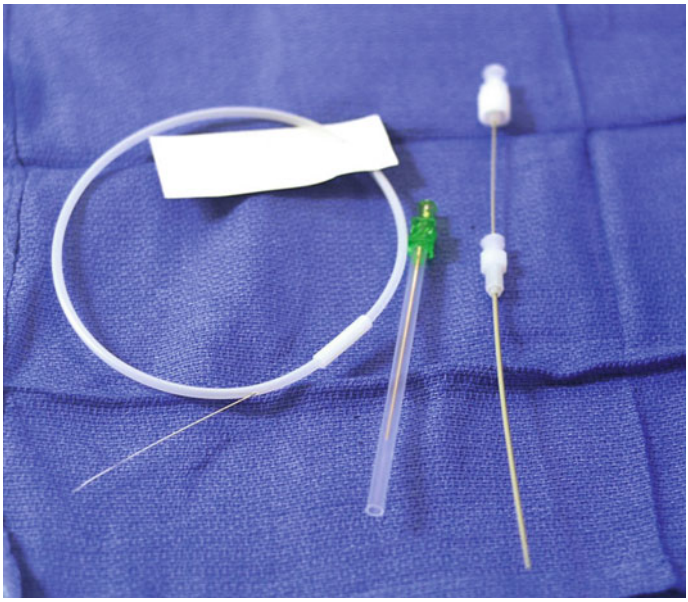

Fig. 2.1 Components of a micropuncture set. The 7 cm 21G needle (*green hub*) is still in a protective sheath that will be discarded when the needle is ready for use. The 40 cm 0.018″ wire is seen exiting its sheath. Once the needle is introduced into the blood vessel, the wire is advanced into the vessel through the needle hub. The needle is then retracted and removed. The micropuncture sheath (*gray*) is seen on the *right side*. The introducer can be seen extending out of its hub. The introducer is advanced fully into the sheath such that its cap securely clips on to sheath hub. The tip of introducer then extends beyond the tip of sheath. This unit is threaded over the wire into the blood vessel. Once the sheath is appropriately positioned, the introducer and wire are simultaneously removed, leaving the sheath in place

- The needle used for puncturing the artery may be from 21 to 23G.
- Using the free right hand, hold the needle with the thumb, index, and middle fingers, with the bevel leading and the opening pointing upwards. Enter through the stab at 45° over the site where arterial pulsations are felt. An indentation in the hub (aligned with the bevel, which should be positioned superiorly) of the needle also assists in correct positioning of the needle tip.
- When the artery is punctured and needle is in its lumen, blood will emanate from the needle hub.
- Stop advancing the needle once within the lumen and avoid going through the facing arterial wall, resulting in a double wall puncture.
- Without moving the needle any further, gently cover the hub with your thumb.
- Use your free hand to pick the provided wire and advance it into the needle hub, introducing it into the arterial lumen (Fig. 2.2b, c, d).
- If any resistance is sensed, fluoroscopically confirm the location and correct intravascular trajectory of the wire (Fig. 2.2e).
- Make sure to have control of some segment of the wire at all times, a part of which should always extend out of the needle hub.

- Once the wire is 5–10 cm into the arterial lumen, retract the needle over the wire (Fig. 2.2f). Make sure to have control of some segment of the wire at all times.
- Introduce the pre-assembled micropuncture sheath with dilator over the wire into the artery (Fig. 2.2g, h). Again, ensure a hold of some segment of the wire at all times and advance the microsheath completely (Fig. 2.2i).
- Withdraw the wire and introducer, leaving the sheath in the artery (Fig. 2.2j, k).
- Cover the hub of the sheath with your thumb to prevent unnecessary blood loss (Fig. 2.2l).
- Introduce a J wire (60–70 cm) into the sheath, until it is in the artery well beyond the sheath (Fig. 2.2m, n). Again, ensure that access is available to some segment of the wire at all times (Fig. 2.2o).
- Maintaining control of wire at all times, retract, and completely withdraw the small sheath over the wire.
- Compress the artery with the same (left) hand which is holding onto the wire to prevent bleeding from the enlarged entrance wound.
- Introduce the 5 Fr or larger sheath over the wire into the arterial lumen (Fig. 2.2p, q, r).
- Retract and remove the wire and sheath introducer, when the sheath has been positioned in the artery (Fig. 2.2s, t).
- Connect the sheath to previously prepared tubing with a neonatal transducer to ensure the continuously running heparinized saline solution is at a rate of 30 ml/hr (Fig. 2.2u).
- Prior to even beginning the procedure, the heparinized saline flush systems for the sheath and at least one catheter should be prepared. It should be ensured that the entire tubing system is free of air bubbles, or any other foreign material (see Chap. 1).
- Make a wet connection so that no air bubbles enter the vascular system (Fig. 2.2v, w, x; also see Chap. 1).
- Secure the sheath by suturing it to the skin using 2-0 silk, or covering it with Tegaderm adhesive to the skin (Fig. 2.2y, z).

Micropuncture Technique

- Use a 21G needle and the 4 Fr micropuncture kit that includes a sheath, dilator, and wire.
- We prefer using micropuncture technique for all elective cases as the arteriotomy puncture is small, with less likelihood of significant blood loss in cases of loss of access during sheath insertion.

Using Single-Wall 18G Needle

- In emergent cases, e.g., stroke where time is of the essence, a larger bore single-wall needle with a J wire or a 0.035 Bentson wire is used to gain a quicker access and place the sheath directly, eliminating the use of the 4 Fr micropuncture set and the involved additional steps.

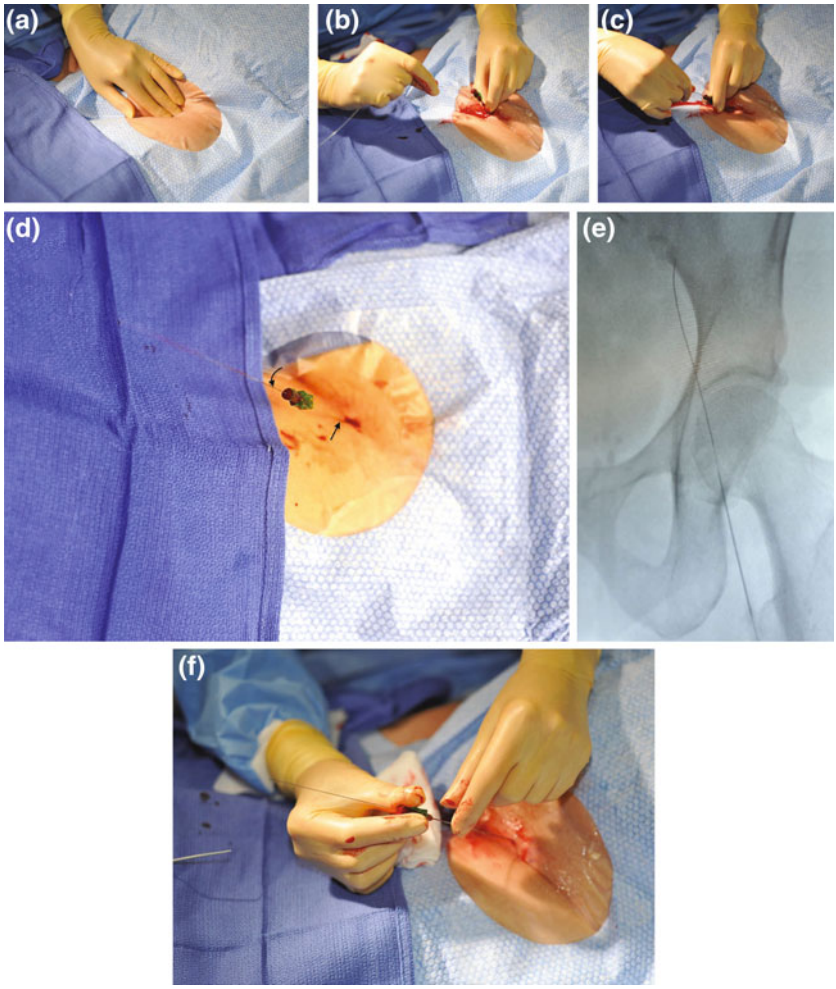

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Fig. 2.2 **a** The pulsations of femoral artery are palpated at the point midway between anterior superior iliac spine and symphysis pubis. **b** The needle is stabilized with one hand as the microwire is introduced into the needle hub with the other and then advanced into the artery **(c)**. **d** The microwire (*curved arrow*) has been introduced into the femoral artery through the micropuncture needle (*arrow*). **e** In case of any resistance, fluoroscopy can be performed to verify that the microwire is indeed intravascular. **f** Once the microwire has secured access to femoral artery, the needle is removed over wire. **g**, **h**, **i** The microsheath unit is then threaded over the wire, taking care that the wire is not inadvertently pulled out of the artery. **j** Following complete insertion of micropuncture sheath, the introducer hub is detached from that of the sheath. As can be seen in the figure, one hand maintains the micropuncture sheath securely in place, while the other withdraws the introducer and wire (obstructed from view by hand) simultaneously. **k** The introducer is almost completely out of the sheath hub, which is maintained in place. The retracting hand is holding on to the introducer hub and wire concurrently. **l** As soon as the wire and introducer are withdrawn, cover the hub of micropuncture sheath with thumb, to prevent unnecessary blood loss.

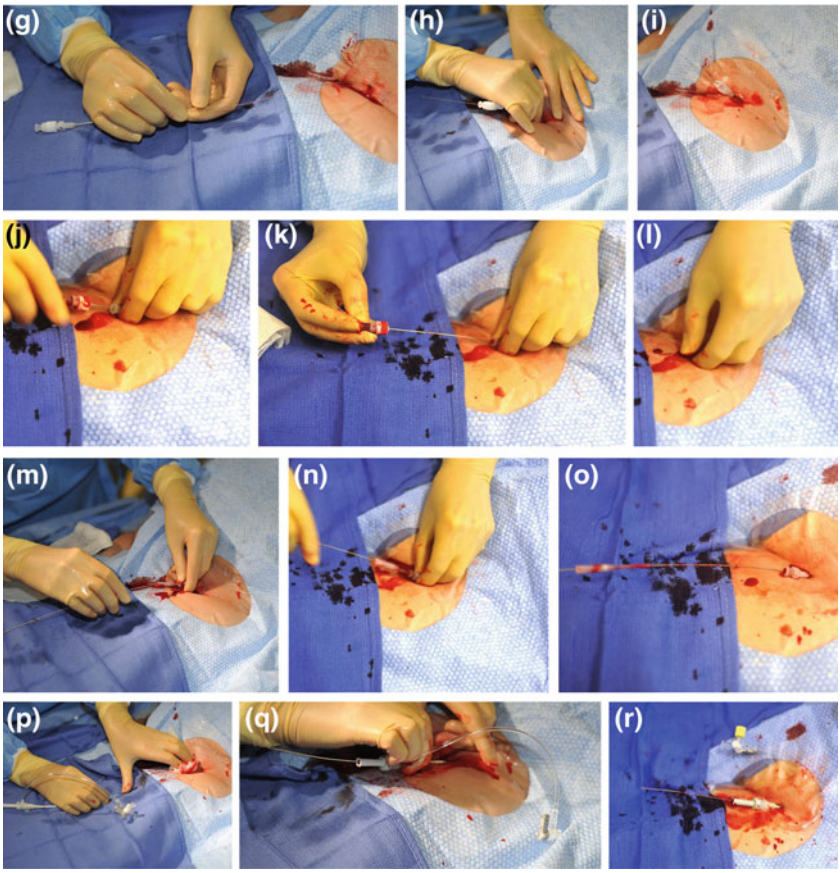

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Fig. 2.2 **m** The J wire is inserted into the microsheath. The white introducer, obvious between the hands, enables easy insertion of the wire into microsheath by straightening out the 'J' shape of the tip. The same can also be done by holding the wire between index finger and thumb and then sliding the thumb back. This movement straightens out the J shape. **n** Advance additional wire further into the sheath, to ensure it extends into the vessel beyond sheath tip. **o** After insertion of the wire into the sheath, adequate length still remains outside, to ensure against inadvertent loss of wire into patient's vasculature. **p**, **q** After removal of the smaller sheath, the sheath to be used for procedure is introduced over the wire and advanced over it into the accessed vessel (**q**). The sheath has its introducer in place, to enable smooth insertion. **r** The sheath is completely advanced into the vessel, such that its hub is right next to the skin. **s**, **t** The wire and introducer are removed from the sheath simultaneously, leaving the sheath in place (**t**). **u** The sheath is connected to a continuously running flush of heparinized saline. **v** It must be ensured the flush system is bubble free. To this end, the three-way stopcock at site of connection has been turned toward the saline flush. This results in back bleeding that exits through the free port. A gauze is used to soak up most of the exiting fluid, in an effort to keep the operative site clean. **w** The three-way stopcock is then turned toward the sheath. This results in occlusion of back bleeding while the saline flush flows out of the free port, cleaning it. The sequence of occluding the flush and then the sheath, washes out any air bubbles, clots or other particles through the free port.

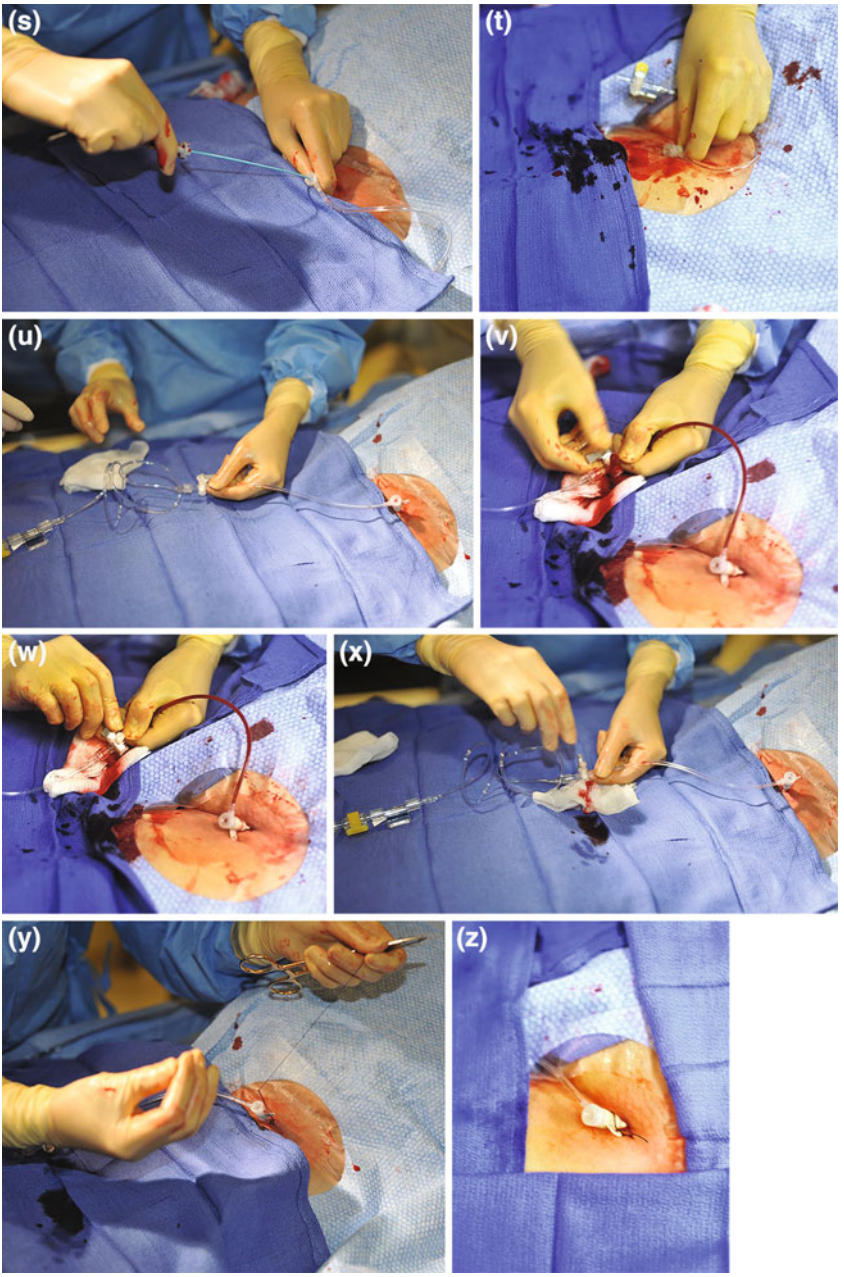

Fig. 2.2 **x** The three-way stopcock is finally turned to freeport, resulting in establishment of continuous heparinized saline flow to the sheath. **y** The sheath is secured by suturing to the patient's skin using the eyelet on the sheath provided for this purpose, to avoid inadvertent dislodgement. **z** Following completion of suturing, the operative site is cleansed. The operator should also ensure her/his gloves are clean, free of blood. Meticulous hygiene is practiced at all times to ensure there is no introduction of clots or foreign bodies into patient's vasculature

  - This may also be helpful when the arterial pulse is not palpable with the smaller access needle.

- Care should be observed to avoid a double puncture of the arterial wall. A punctured bleeding site, unsecured by angioseal or similar means, may be a cause of significant bleeding, especially in patients who have received heparin, TPA, or similar blood thinners for the intervention.

Using Image Guidance in Difficult Access

- If difficulty is because of inability to palpate the femoral artery pulse, use the anatomic landmarks, e.g., if the thumb of your hand is on the patient's anterior superior iliac spine and the hand spans across such that the little finger is on the symphysis pubis, the location of the artery is demarcated by using the index finger of the other hand to bisect the hand span.
- If the femoral vein is entered, retract and clean the needle. Apply manual pressure on the vein for a minute, or so. Then, direct the needle slightly lateral to the previous course, as the femoral artery lies lateral to the vein.
- Ultrasound may be used to access a difficult artery (Fig. 2.3).
- A 5–10 MHz linear probe is used for femoral artery with a depth setting of 2–3 cm.
- It is placed in a sterile sheath with transmission gel applied to it (Fig. 2.3a, arrow).

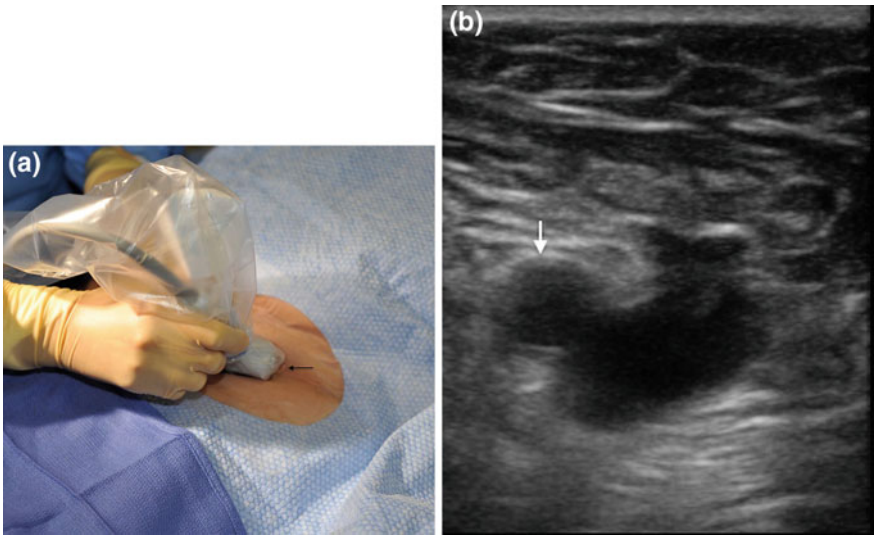

Fig. 2.3 **a**, **b** An ultrasound probe in a sterile sheath may be used to locate the femoral artery and access it, in case of difficulty feeling arterial pulse. Ultrasound gel is used (*arrow*) to enable satisfactory conduction. **b** Femoral artery (*arrow*) and vein can be seen side by side. The artery is recognizable by its more circumferential shape and pulsations. The needle can be advanced into the artery by visualizing its shadow as it is advanced and guided into the vessel

- Apply the probe at the level estimated to be superior to femoral bifurcation.
- The probe is applied transverse to the course of the artery, resulting in visualization of axial plain.
- The artery will be superficial to the vein, and more circumferential.
- The vein is more readily compressible by application of pressure using the probe.
- If the site interrogated is at or inferior to femoral bifurcation, two arterial circumferences will be seen.
- Introduce the needle into the skin inferior/caudal to the probe and advance it toward the artery at about 40° angle.
- The anterior wall of the artery is kept under the central target line (markers visualized as dots/circles), which indicates the path of the needle.
- Blood will emanate from the needle hub, once vessel has been entered.
- If difficulty is encountered during insertion of sheath over the J wire or, during exchange to a larger sheath over a wire:

  - Use fluoroscopy to ensure the J wire is in appropriate position.
  - Use a mosquito forceps to dilate the stab incision/subcutaneous tissue that may be providing resistance to the advancing sheath. This may happen due to scarring from previous procedures or tension in the deep fascia.
  - If a smaller size sheath is already in place, e.g., the 4 Fr sheath from the micropuncture kit, perform angiography through it to assess for stenosis or dissection.
  - In case of difficulty upsizing to a larger sheath, e.g., from 5 to 6 Fr, use a 5 Fr dilator over the wire, followed by 6 Fr dilator, if needed, and then reattempt insertion of the 6 Fr sheath.
  - A stiff 5 Fr micropuncture sheath can also usefully function as a dilator when resistance from scar tissue is encountered.

Radial Access

- Radial access is usually elected when vascular anatomy makes intervention difficult by the femoral route (i.e., aortic coarctation or, subclavian stenosis). Other situations that may require opting for radial access include skin infection in the femoral region or, unusual obesity rendering femoral access very difficult, if not impossible.
- Prior to performing arteriotomy, perform Allen's test with pulse oximetry to ensure the hand has satisfactory vascular supply, just in case the procedure results in radial artery occlusion.

Allen Test

- Palpate the radial and ulnar arteries.
- Place a pulse oximeter on the thumb or index finger.
- Make the patient flex and extend their fingers repeatedly.

- With digital pressure, compress both the radial and ulnar arteries during finger extension and maintain the compression until the oximetry pulse is lost.
  - Ensure the wrist is maintained in approximately 20° flexion, in order to avoid false positive tests which may happen with wrist hyperextension.
  - Release the pressure on the ulnar artery. Measure the time taken to achieve visual capillary refill in finger pads and at least 92% oxygen saturation.
  - Normal capillary refill time is <5 s, refill times of 5–15 s are considered equivocal. A refill time longer than 15 s is abnormal.
  - Allen's test can also be performed using ultrasonography.

Reverse Allen Test

- This should be performed when the radial artery is being subjected to a repeat procedure.
- With digital pressure, compress both the radial and ulnar arteries during finger extension and maintain the compression.
- Ensure the wrist is maintained in approximately 20° flexion, in order to avoid false positive tests that may happen with wrist hyperextension.
- Release the pressure on the *radial* artery. Measure the time taken to achieve visual capillary refill in finger pads and at least 92% oxygen saturation.
- Normal capillary refill time is <5 s, refill times of 5–15 s are considered equivocal. A refill time longer than 15 s is abnormal.
- An abnormal filling time indicates proximal radial artery disease. Therefore, repeat procedure on the artery should be avoided.

Access Technique

- Maintain the forearm in supine position.
- If required, use towels under the wrist to support it.
- The hand and or forearm may also be taped down to maintain supine position.
- Anesthetize the skin overlying the radial artery using 0.5 or 1% lidocaine.
- Take care not to puncture the artery, or cause it to go into spasm.
- Use two fingers to immobilize the arterial segment to be catheterized.
- As described above for femoral artery catheterization, use modified Seldinger technique and perform arteriotomy with a micropuncture set to secure arterial access.
  - Do not attempt arterial access with a larger bore single-wall needle.
  - Avoid entering the needle into artery at a steep angle, as this may cause difficulties in threading the wire through the artery. Remember, the radial artery is much smaller than femoral.
- Advance the 0.018″ wire through the needle hub into the radial artery and remove the needle.

- Use the tip of the scalpel blade to make a nick in the skin over the wire, to aid in smoother insertion of larger sheaths. This nick can also be made prior to arteriotomy with needle, provided it is done carefully and not going too deep.
- Advance the 4 Fr micropuncture sheath (with dilator) over the wire.
- Remove the wire and dilator.
- Advance 0.035″ wire through the sheath and then remove the sheath over the wire.
- A 5 Fr or 6 Fr sheath may be placed in radial artery, provided upsizing is performed after placing a 4 Fr catheter.
- Prior to upsizing, administer a cocktail of heparin (5000 IU/ml), verapamil (2.5 mg), lidocaine (2%, 1.0 ml), and nitroglycerin (0.1 mg) through the introducer sheath to relieve and/or prevent vasospasm.

  – Forewarn the patient about an uncomfortable but transient sensation of severe burning as the cocktail is injected into the artery. Usually analgesic administration prior to cocktail injection in unnecessary because of the very transient nature of the sensation.

- Following completion of procedure, *Do Not* use angioseal or similar device for arteriotomy closure.
- Use manual compression only and apply pressure for 15–20 min, until hemostasis is achieved.
- In order to decrease the likelihood of radial artery occlusion, use the smallest size of sheath through which the procedure can be performed. We usually use a 4 Fr or 5 Fr sheath.

Brachial Access

- If possible, avoid the use of brachial artery. However, sometimes its use may become necessary, e.g., unavailable femoral and radial arteries.
- The access method is the same as for femoral artery, using modified Seldinger technique.
- Preferably start with a 4 Fr micropuncture kit, unless the situation is urgent and access with the larger single-wall needle appears reasonably assured.
- The use a closure device in the brachial artery is not presently FDA approved.
- Apply manual compression for approximately 15 min after the sheath is removed.

Carotid Access

- Carotid Access is best avoided because of the high risk of potential emboli going directly to the cerebral circulation during the puncture and the risk of ante grade dissection. This embolic risk is mitigated the farther the access arteriotomy is from the cerebral circulation. Furthermore, dissection in a vessel such as femoral artery would be retrograde, amenable to self-repair.

- If necessary, access is obtained by using modified Seldinger technique as described above for femoral artery.
- It may be advantageous, especially for the interventionists with neurosurgical background to make an incision and dissect to perform a direct exposure of the carotid artery.
- Arterial access should be performed at the Common carotid artery rather than the internal carotid.
- Usually the vessel is of sufficient caliber and superficial enough that access may be commenced with an 18G single-wall needle.
- Be very careful not to advance the J wire beyond the cervical carotid.
- Confirm the location of the tip of the J wire using fluoroscopy.
- Do not use a closure device for closure. Instead, apply manual compression.
- Ensure that the contralateral carotid is not being compressed concurrently.
- Conversely, if a cut down to the carotid was performed, then a purse string suture using 4-0 prolene is applied for closure.

Choice of Sheath or Access Device

- When performing a procedure electively, we gain access with a single-wall 21G needle 7 cm in length, using it with a 4 Fr micropuncture set. This results in less trauma to the femoral artery, and the lack of double puncture eliminates the risk of persistent bleeding in a heparinized patient.
- In emergency cases, e.g., when performing an intervention in stroke patients a larger 18G needle with 0.035 glidewire may be used, instead of the 21G needle with micropuncture set.
- Usually a 5 Fr Short sheath suffices for diagnostic procedures (e.g., an 11 cm length sheath).
- At least a 6 Fr sheath will be needed for most interventional procedures.
- In case of stroke where use of larger caliber devices is anticipated, we usually insert at least a 7 or 8 Fr sheath from the very outset.
- Use a longer sheath when the patient has a tortuous vasculature, e.g., elderly patients. In such situations use at least a 22 cm sheath, instead of the usual 11. A longer sheath will eliminate the tortuosity of segment traversed by it, making the navigation and manipulation of a catheter further distally, easier.
- When the vasculature is particularly tortuous or, in procedures such as stenting where the stability of catheters and devices is imperative, use a 60 cm shuttle sheath (see Chap. 5 for further details and examples of different types and sizes of sheaths).

Problems Encountered and Solutions

- Table 2.1.

Table 2.1 Problems and maneuvers

Problem	Maneuver
Resistance is felt on advancing the Microguidewire (0.018″) through the needle	• Stop, as soon as any resistance is felt. Perform fluoroscopy to ascertain the location of the wire (Fig. 2.2e). If the guidewire appears crumpled up, retract and discard. If blood is no longer emanating from the needle hub, it indicates that arterial access has been lost. Retract the needle and apply pressure for a couple of minutes on the puncture site. Clean the needle and reattempt arteriotomy • If blood is still emanating from the hub after the microwire is removed, it is indicative of the needle still being in the artery. Ensure that bevel of the needle is directed superiorly (by checking that the divot of the hub is pointing up). Drop your hand slightly if the angle appears too steep. If angle was appropriate and divot was pointing superior, rotate the needle slightly to change the direction of bevel. After confirming blood is still emanating from the hub, advance a fresh microwire through the needle into the vessel
The wire initially advanced through the sheath, but then resistance was encountered	• This may happen with the microwire or the J wire. A common reason could be the wire advancing laterally into a branch such as circumflex iliac artery, instead of medially into the external iliac artery. Retract the wire partially so that it is out of the selected branch and back in the femoral artery. Attempt to advance the wire medially under direct fluoroscopy while rotating it back and forth at its distal end, to select the correct direction. The sheath may need to be retracted back slightly and then advancement of the wire attempted. If this is unsuccessful, retract and remove the wire and perform angiography to assess the cause of resistance. The angiogram can be used as a roadmap (e.g., 'smartmask' feature on the Phillips system). Do not give up access, unless it is inevitable based on site or arteriotomy. If the resistance is because of significant stenosis in the femoral or iliac artery, consider using access through the contralateral vessel
Previously palpable pulse is lost	• Inspect the skin distal to arteriotomy on the affected extremity. If it appears well perfused and with good capillary refill, observe • Obtain a peripheral vascular consult • If punctate mottling of digital skin alone is seen, close observation alone may suffice and no further action may be necessary • If the extremity appears compromised, perform angiography to inspect the cause of vascular compromise. Consider the following options:

(continued)

Table 2.1 (continued)

Problem	Maneuver
	– For femoral artery compromise, perform arteriotomy on the contralateral femoral artery and navigate the catheter into the affected vessel staying proximal to the site of suspected injury and perform angiography – For radial artery, consider retrograde angiography via the brachial or subclavian artery – If angiography demonstrates a thrombus, local intra-arterial TPA may be administered – If angiographic appearance is consistent with a dissection, stenting with or without angioplasty is an option. Since neurointerventionists usually have limited experience of peripheral vasculature, requesting consultation from a peripheral interventionist may be prudent
Persistent bleeding despite adequate Angioseal deployment	• Ensure the appropriate size closure device is selected. The size should be the same or larger than the sheath placed in the vessel. Sometimes, due to use of Heparin or thrombolytics, persistent oozing is encountered. This is usually innocuous and is addressed by applying a few minutes of manual compression followed by pressure dressing. Such oozing will abate after the anticoagulant/thrombolytics are stopped. In case of overnight heparinization to prevent embolic complications, it is usually unnecessary to stop the medication for a mild continuous ooze
Plug pulls out of arteriotomy during deployment	• Ensure the appropriate size closure device is selected. When this occurs, arterial access has already been lost. Therefore, manual compression is applied for at least 20 min. If necessary, manual compression may be followed by usage of Femostop esp. if therapeutic dose of blood thinners have been used during intervention • In case a Femostop is used, ensure that proper positioning over arteriotomy site is maintained. To achieve this, the see-through inner circle of the Femostop dome should be positioned 1 cm superior and 1 cm medial to the actual puncture site. Inflate the Femostop to 20–30 mm Hg above the patient's systolic pressure. If this does not result in hemostasis, inflate to higher pressures until distal pulses are occluded. Maintain distal pulse occlusion for 5–7 min, then readjust the manometer pressure until good pedal pulse and good color of extremities is achieved. Once hemostasis occurs, reduce manometer pressure to half the number and observe the site for 2–3 min • Additionally, continue to check the pressure applied, as the device may have a tendency to deflate spontaneously. Continue to progressively decrease the applied pressure over the course of several hours, until the device can be discontinued entirely

(continued)

Table 2.1 (continued)

Problem	Maneuver
	• Usually, a Femostop is maintained for 6–12 h
Patient complaining of weakness, nausea, dizziness or rapid pulse with/without hypotension	• First and foremost ensure the patient is not continuing to lose blood from the arterial puncture site causing a retroperitoneal hematoma. This problem is more likely to be encountered following an interventional procedure, rather than a diagnostic one. These symptoms may occur within hours to several days following the procedure. The symptoms may be no more than a vasovagal response. However, the possibility of persistent blood loss needs to be ruled out. Do the following: – Monitor pulse, BP continuously, until condition diagnosed or ruled out – Send labs including CBC, electrolytes, aPTT, INR and if need be cardiac enzymes and troponins – Perform EKG – Insert foley catheter – Monitor intake and output – Administer 1 litre bolus of 0.9% normal saline and then a continuous running infusion at 125–150 ml/h – A smaller or larger bolus may be administered depending on the patients' clinical condition, e.g., a smaller bolus may be prudent in a hemodynamically stable patient with CHF. Similarly, the infusion rate may be titrated depending on the individual patient. However, it is better to aggressively overhydrate rather than under resuscitate the patient, which may compound the initial problem further, e.g., onset of ARF – Perform ultrasonography to rule out femoral pseudoaneurysm. The ultrasonography may also prove therapeutic as the USG probe may be used to compress and occlude the femoral artery pseudoaneurysm – If the ultrasound is negative and the suspicion of pseudoaneurysm remains, obtain an abdominal-pelvic CT scan – Usually the presence of pseudoaneurysm or retroperitoneal hematoma only requires supportive care including, IV fluids with/out PRBC – However, obtain a vascular consult in case surgical/endovascular intervention for treating the pseudoaneurysm is required

Suggested Reading

Levy EI, Boulos AS, Fessler RD, Bendok BR, Ringer AJ, Kim SH, et al. Transradial cerebral angiography: an alternative route. Neurosurgery. 2002;51:335–42.

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